PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY
(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference PC-21004610	FOR FURTHER ACTION See Form PCT/IPEA/416	
International application No. PCT/SE2003/001229	International filing date *(day/month/year)* 21-07-2003	Priority date *(day/month/year)* 31-07-2002
International Patent Classification (IPC) or national classification and IPC H02P9/14		
Applicant Sydkraft AB et al		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 4 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *(sent to the applicant and to the International Bureau)* a total of 5 sheets, as follows:
      ☒ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s))
      _____, containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).
4. This report contains indications relating to the following items:
   - ☒ Box No. I Basis of the report
   - ☐ Box No. II Priority
   - ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - ☐ Box No. IV Lack of unity of invention
   - ☒ Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - ☐ Box No. VI Certain documents cited
   - ☐ Box No. VII Certain defects in the international application
   - ☐ Box No. VIII Certain observations on the international application

Date of submission of the demand	Date of completion of this report
13-02-2004	17-09-2004
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Form PCT/IPEA/409 (cover sheet) (January 2004)

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/SE2003/001229

Box No. I Basis of the report

1. With regard to the language, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ This report is based on a translation from the original language into the following language _____, which is the language of a translation furnished for the purposes of:

- ☐ international search (under Rules 12.3 and 23.1(b))
- ☐ publication of the international application (under Rule 12.4)
- ☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the elements of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report):*

☐ the international application as originally filed/furnished

☒ the description:

pages 29 as originally filed/furnished
pages* _____ received by this Authority on _____
pages* _____ received by this Authority on _____

☒ the claims:

pages _____ as originally filed/furnished
pages* _____ as amended (together with any statement) under Article 19
pages* 30-34 received by this Authority on 27-07-2004
pages* _____ received by this Authority on _____

☒ the drawings:

pages 6 as originally filed/furnished
pages* _____ received by this Authority on _____
pages* _____ received by this Authority on _____

☐ a sequence listing and/or any related table(s) – see Supplemental Box Relating to Sequence Listing.

3. ☐ The amendments have resulted in the cancellation of:

- ☐ the description, pages _____
- ☐ the claims, Nos. _____
- ☐ the drawings, sheets/figs _____
- ☐ the sequence listing *(specify)*: _____
- ☐ any table(s) related to the sequence listing *(specify)*: _____

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

- ☐ the description, pages _____
- ☐ the claims, Nos. _____
- ☐ the drawings, sheets/figs _____
- ☐ the sequence listing *(specify)*: _____
- ☐ any table(s) related to the sequence listing *(specify)*: _____

* *If item 4 applies, some or all of those sheets may be marked "superseded."*

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/SE2003/001229

Box No. V **Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	1-25	YES
	Claims		NO
Inventive step (IS)	Claims	1-25	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-25	YES
	Claims		NO

2. Citations and explanations (Rule 70.7)

The claimed invention relates to controlling a rotating synchronous machine. In particular, the invention concerns machines for reactive power compensation. For safety reasons such machines are over-dimensioned. The object of the invention is to be able to use the machines more efficiently within safe margins. This is accomplished by controlling the machines while monitoring the temperature in critical machine parts.

Document cited in the International Search Report:

D1) WO 0117092 A1
D2) "Monitoring the thermal condition of permanent-magnet synchronous motors" Milanfar P et al.
D3) WO 0117085 A1
D4) WO 0067358 A1
D5) US 5321308 A
D6) "Calculation of temperature rises due to conductor losses in a radially-cooled turbogenerator rotor" Stephenson P.L.

D1 discloses a method for monitoring an electric power network. The existent resources are used more effectively. This is accomplished by directly measuring critical quantities, above all the temperature in parts of a generator, which are difficult to access. These data, rather than rated data, are used for controlling the system.

D2 describes a thermal model of a Permanent Magnet Synchronous Motor. The model is based on line current and line voltage measurements. The model is fairly crude, but is suggested that more complex models could be used to consider localized

.../...

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of: Box V

temperature variations directly (footnote page 1423).

The method defined in new independent claims (dated 2004-07-27) 1, 4, 16, 17 and 20-24 explicitly defines that the temperature in at least two spots are estimated, that a coolant temperature is measured and that the rotor current is measured. These features are not found in the combined teachings of D1 and D2. The fact that a coolant is used clearly indicates that the invention concerns rather large rotating electric machines, possibly used in a power network, while D2 concerns modelling a comparatively small permanent magnet motor. It would require more than ordinary skill to combine D1 and D2 and also realise the necessity of adding the remaining features of the independent claims. Consequently, the invention according to new independent claims 1, 4, 16, 17 and 20-24 is considered to involve an inventive step.

The invention according to new claims (dated 2004-07-27) 1-25 is novel and it is considered to involve an inventive step. It is also industrially applicable.

CLAIMS

1. A method of monitoring a rotating synchronous electric machine (9), which comprises a rotor having a rotor winding and a stator having a stator winding, wherein the electric machine is cooled by at least one coolant, the method comprising the steps of

determining the stator winding current,

determining the stator winding voltage,

determining the rotor winding current,

measuring the coolant temperature, and

estimating the temperature in at least two positions in the electric machine (9) using a theoretical model of the electric machine, the determined current and voltage values, and the measured temperature of the coolant.

2. The method according to claim 1, which method further comprises the step of measuring the temperature in at least one point in the machine and wherein the temperature estimates are effected also in dependence on the measured temperature.

3. The method according to claim 1 or 2, wherein the rotor and the stator are divided into a number of zones, wherein the temperature is estimated for each zone.

4. A method of controlling at least one variable in a rotating synchronous electric machine (9), which comprises a rotor having a rotor winding and a stator having a stator winding, and the electric machine is cooled by at least one coolant, the method comprising the steps of

determining the stator winding current,

determining the stator winding voltage,

determining the rotor winding current,

measuring the temperature of the coolant, and

estimating the temperature in at least two positions in the electric machine (9) using a theoretical model of the electric machine and in dependence on the determined current and voltage values and the measured coolant temperature, and

controlling said at least one variable in dependence on the estimated temperatures and using the model of the electric machine.

5. The method according to claim 4, wherein controlling said at least one variable comprises controlling in such manner that at least one of the estimated temperatures is kept essentially constant.

6. The method according to claim 4 or 5, which method further comprises the step of measuring the temperature in at least one point in the stator and wherein the control of said at least one variable is effected also in dependence on the measured temperature.

7. The method according to any one of claims 4-6, which further comprises the step of measuring the temperature of the medium surrounding the electric machine and wherein the control of said at least one variable is effected also in dependence on the measured ambient temperature.

8. The method according to any one of claims 4-7, wherein controlling said at least one variable comprises controlling the current supplied to the rotor.

9. The method according to any one of claims 4-8, wherein controlling said at least one variable comprises controlling the supplied cooling effect.

10. The method according to any one of claims 4-9, wherein the electric machine is a generator and wherein controlling said at least one variable comprises controlling the supplied power.

11. The method according to any one of claims 4-9, wherein the electric machine is an electric motor and wherein controlling the electric motor comprises controlling the load.

12. The method according to any one of claims 4-11, wherein control is effected by means of a first allowable temperature and a second allowable temperature, wherein control is effected in such manner that said estimated temperatures are allowed to reach the first allowable temperature as a steady value and that said estimated temperatures are allowed to reach the second allowable temperature only for a predetermined period of time.

13. The method according to any one of claims 4-12, wherein the rotor and the stator are divided into zones, wherein the temperature is estimated for each zone.

14. The method according to any one of claims 4-13, wherein the temperature of at least one of a bus-duct (IPB), a generator circuit breaker (GCB) and a generator step-up transformer (GSU) is measured and used to control the generator output.

15. The method according to claim 14, wherein the temperature of at least one of the bus-duct (IPB), the generator circuit breaker (GCB) and the generator step-up transformer (GSU) is measured and used to control the cooling power for at least one of the bus-duct (IPB), the generator circuit breaker (GCB) and the generator step-up transformer (GSU).

16. A control apparatus for controlling a rotating synchronous electric machine, characterized in that the electric machine is cooled by at least one coolant, wherein the temperature of the coolant is measured, and the electric machine comprises at least stator current, stator voltage, rotor current, and coolant temperature

signal inputs, and that the control apparatus is arranged to transmit control signals for controlling at least one variable in the electric machine in dependence on the signals on the signal inputs and using a model of the electric machine, which model is used to estimate the temperature in at least two positions in the electric machine.

17. An apparatus for monitoring a rotating synchronous electric machine, characterized in that the electric machine is cooled by at least one coolant, wherein the temperature of the coolant is measured, and the electric machine comprises at least stator current, stator voltage, rotor current, and coolant temperature signal inputs and that the control apparatus is adapted to estimate the temperature in at least two positions in the electric machine in dependence on the signals on the signal inputs and using a model of the electric machine.

18. The apparatus according to claim 17, which further comprises a storage means, the estimated temperatures being stored in the storage means.

19. The apparatus according to claim 17 or 18, which further comprises a display means on which the estimated temperatures are displayed.

20. A power plant for generating electric power, comprising a turbine and a generator connected thereto, and a control apparatus as claimed in claim 16.

21. A synchronous compensator for synchronous compensation, which is controlled by means of a control apparatus as claimed in claim 16.

22. Use of a method as claimed in any one of claims 1-15 in a power plant for generating electric power, which power plant comprises a turbine and a generator connected thereto.

23. Use of a method as claimed in any one of claims 4-15 for controlling an electric synchronous motor.

24. A memory medium on which a computer program is stored for controlling a rotating synchronous electric machine, which comprises a rotor having a rotor winding and a stator having a stator winding, and the electric machine is cooled by at least one coolant, characterized in that the computer program when executed on a computer causes the computer to

receive an input signal containing stator winding current data,

receive an input signal containing stator winding voltage data,

receive an input signal containing rotor winding current data,

receive an input signal containing coolant temperature data, and

estimate the temperature in at least two positions in the electric machine using a theoretical model of the electric machine and the data of the received input signals.

25. The memory medium according to claim 24, wherein the program is further adapted to cause the computer to transmit an output signal for controlling the electric machine in dependence on the estimated temperatures when executed.